Possible Modulation of Acrylamide Through Cooking Practices

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Yum! Brands Presentation for OEHHA Workshop

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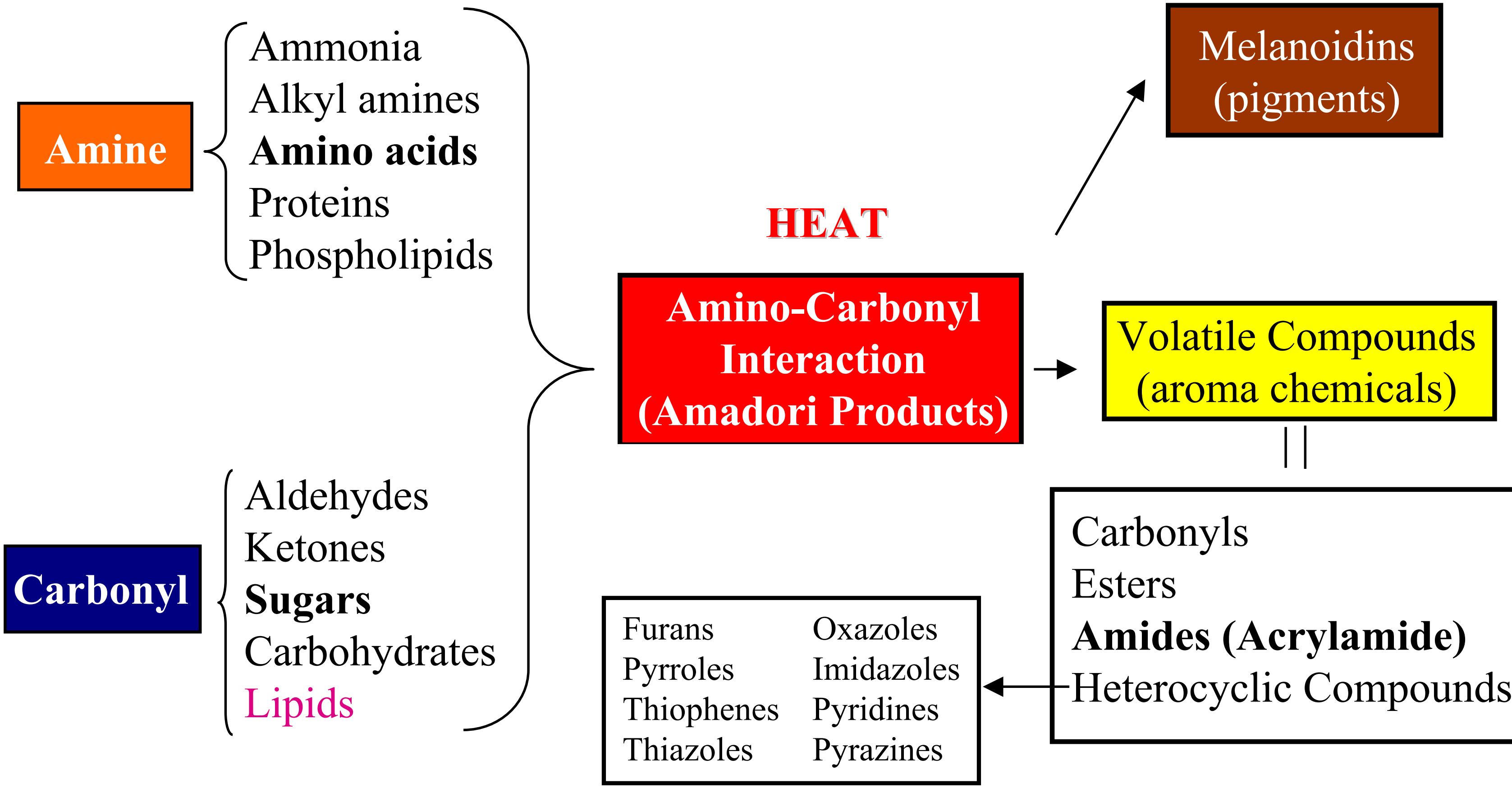
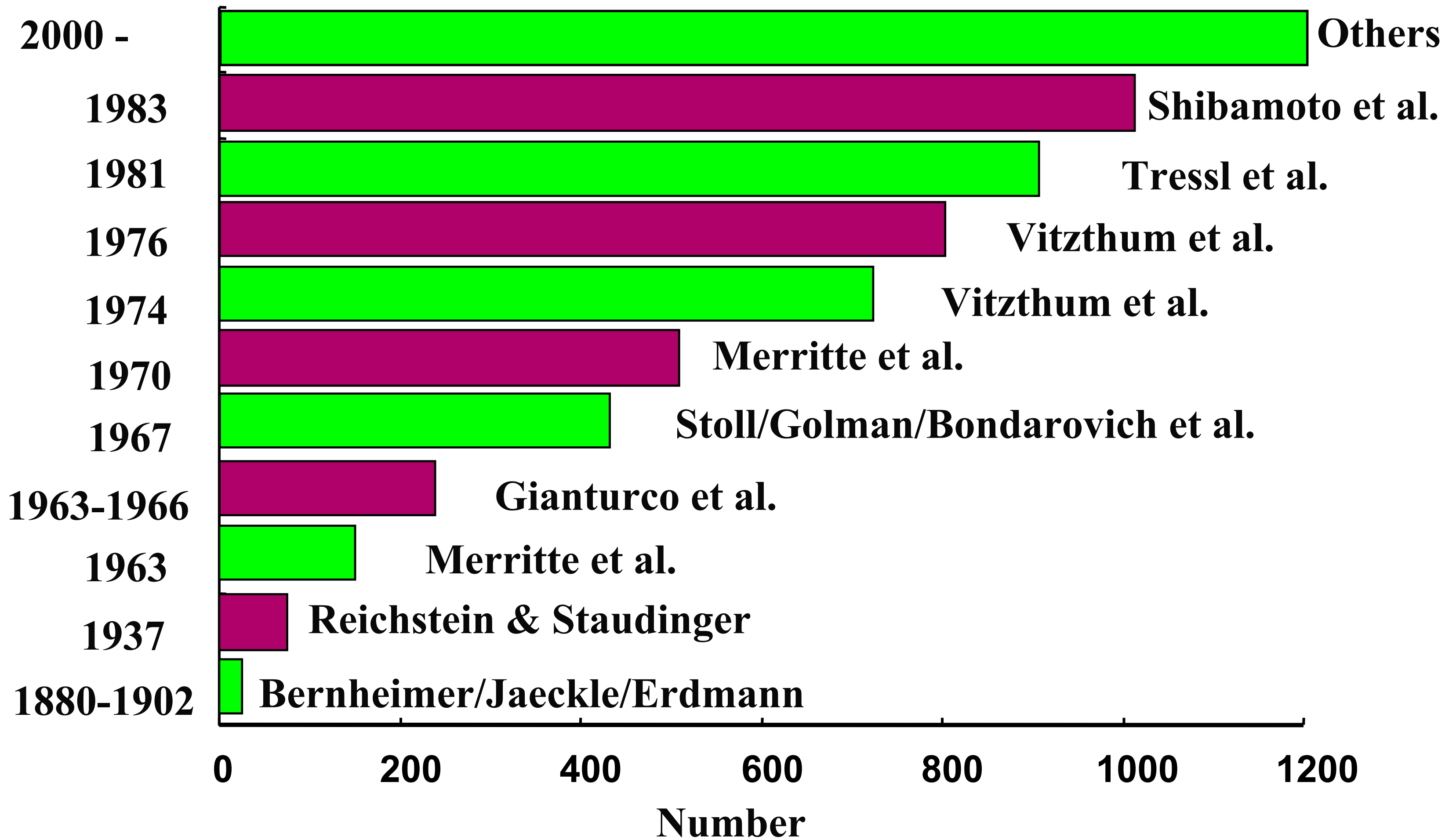
General Scheme of Maillard Browning Reaction



Browning Food Creates Palatability

- **Palatability determines the desirability/acceptability of food in consumers**
- **Palatable cooked food is a combination of factors:**
  - **Color -- 80% of food desirability is based on appearance**
  - **Taste/Flavor**
  - **Aroma**
  - **Texture**
- **Palatability comes from the presence of literally thousands of chemicals created during the cooking process**
- **The Maillard browning reactions play a <u>major</u> role in creating those palatability**

Approximate Number of Chemicals Found in Browning Reaction

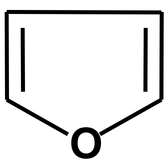


Browning Creates Antioxidants

- Antioxidants are chemicals with known health benefits
  - Vitamin A
  - Vitamin C
  - Vitamin E
  - Flavonoids
  - Polyphenols
- Browning produces antioxidants: Starting in the 1990s, my research has shown the formation of powerful antioxidants during the browning process

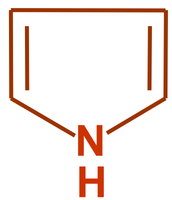
Typical Heterocyclic Compounds and Their Characteristic Flavor

Furan



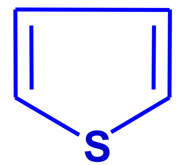
Sweet
Caramel-
like

Pyrrole



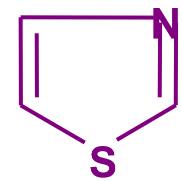
Sweet
Ethereal;
Burnt

Thiophene



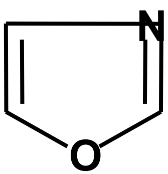
Onion-
Like
Sulfurous

Thiazole



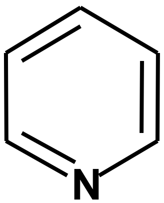
Cooked-
meat
Sulfurous

Oxazole



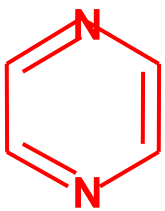
Sweet
Roasted

Pyridine



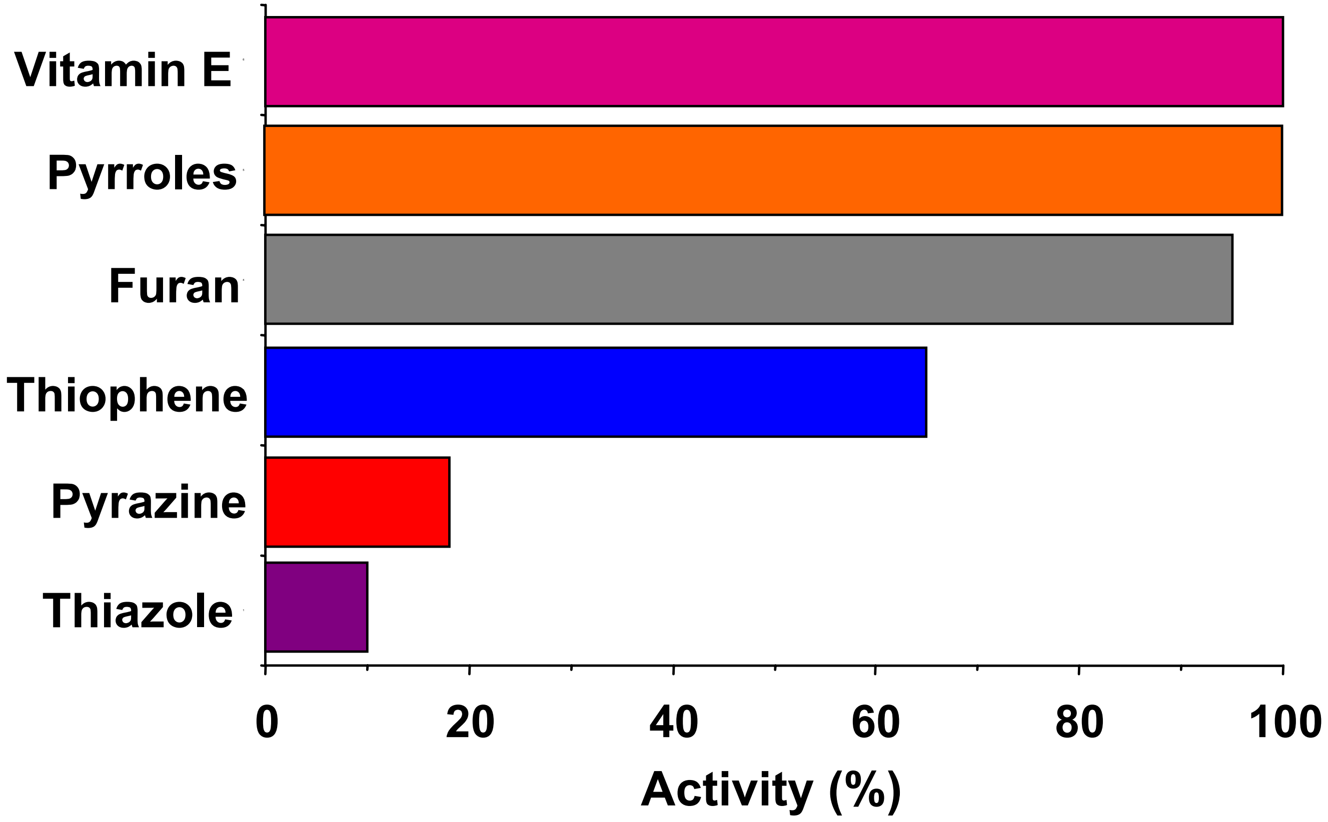
Pungent
Smokey
Fishy

Pyrazine

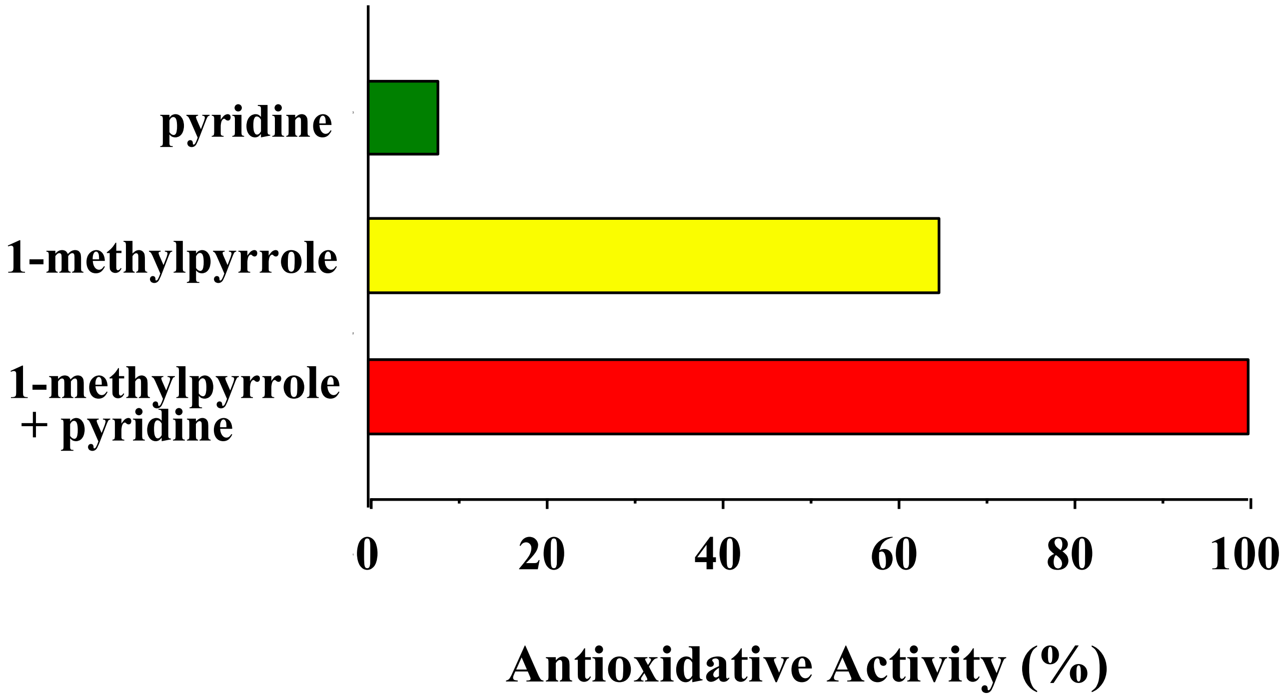


Roasted
Toasted
Cooked

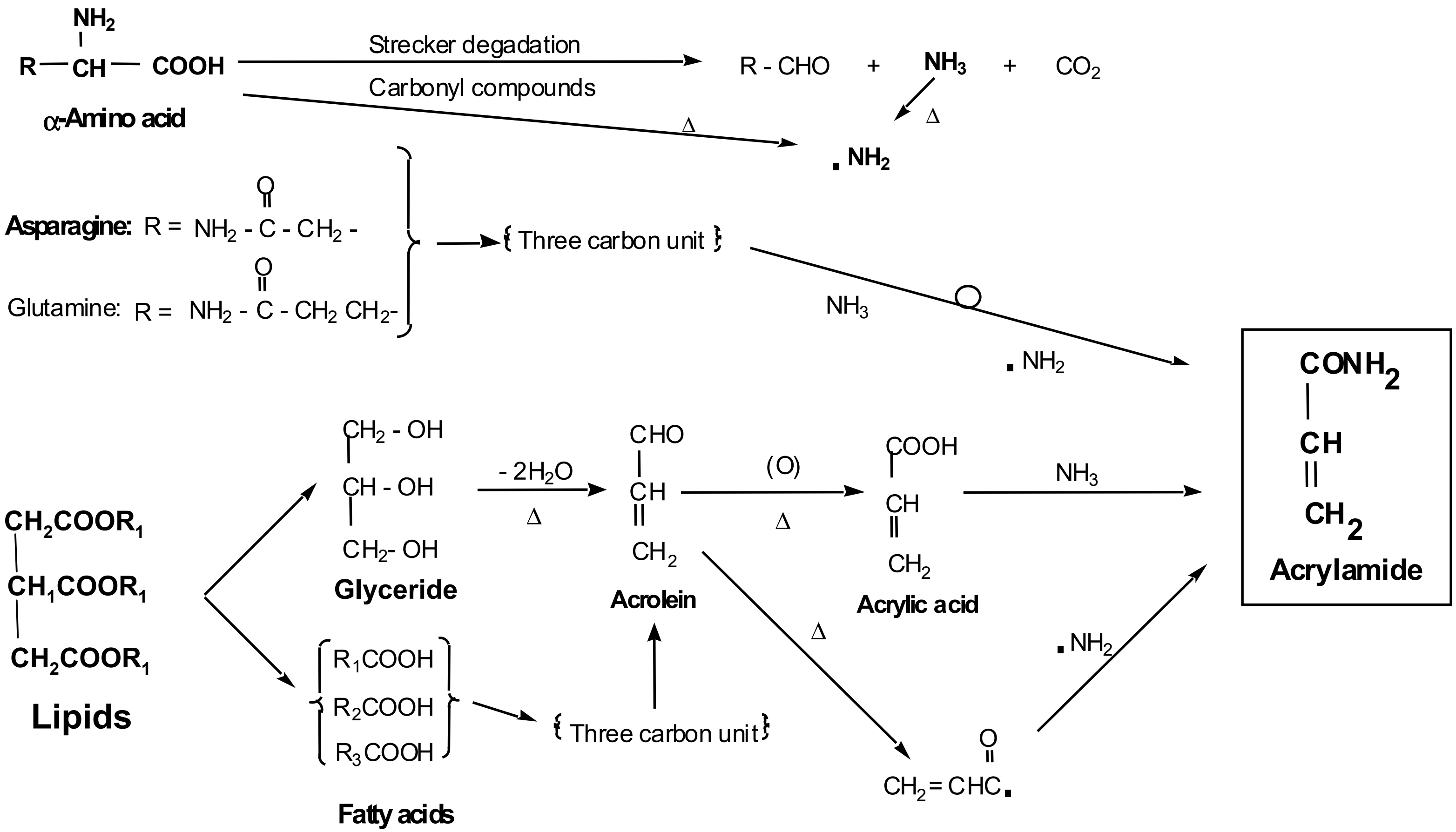
Antioxidative Activities of Heterocyclic Compounds



Synergistic Antioxidative Activities of Pyridine and 1-Methylpyrrole



Proposed Formation Mechanisms of Acrylamide



Triolein: R_1, R_2, R_3 = $(CH_2)_7CH = CH(CH_2)_7CH_3$

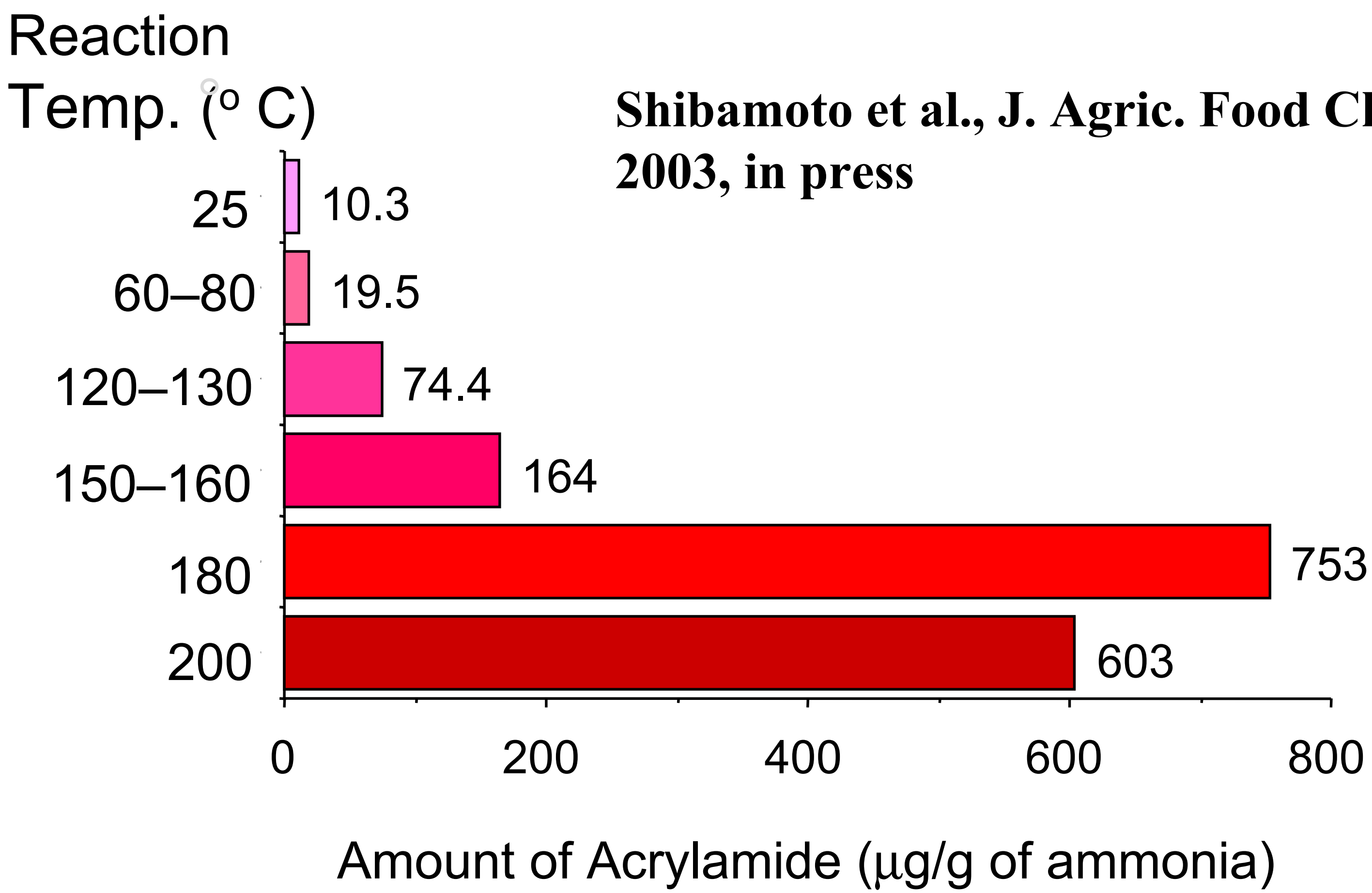
Acrylamide Formed in Browning Model Systems

Reactants		Temp. (^oC)	Amt. of Acrylamide (µg/g of amine)
Amines (amount)	Carbonyls (amount)		
asparagine (1.76 g)	–	180	0.99
asparagine (1.76 g)	triolein (5 g)	180	88.6
glutamine (2 g)	–	180	0.17
glutamine (2 g)	triolein (5 g)	180	3.53
asparagine (1.76 g)	acrolein (0.878 g)	180	114
glutamine (2 g)	acrolein (0.878 g)	180	0.18
asparagine (1.76 g)	glucose (2 g)	180	1,200
ammonia (0.329 g)	**acrylic acid** (2 g)	180	**190,000**

Shibamoto et al., J. Agric. Food Chem. 2003, in press

Acrylamide Formed from Ammonia/Acrolein

Shibamoto et al., J. Agric. Food Chem. 2003, in press



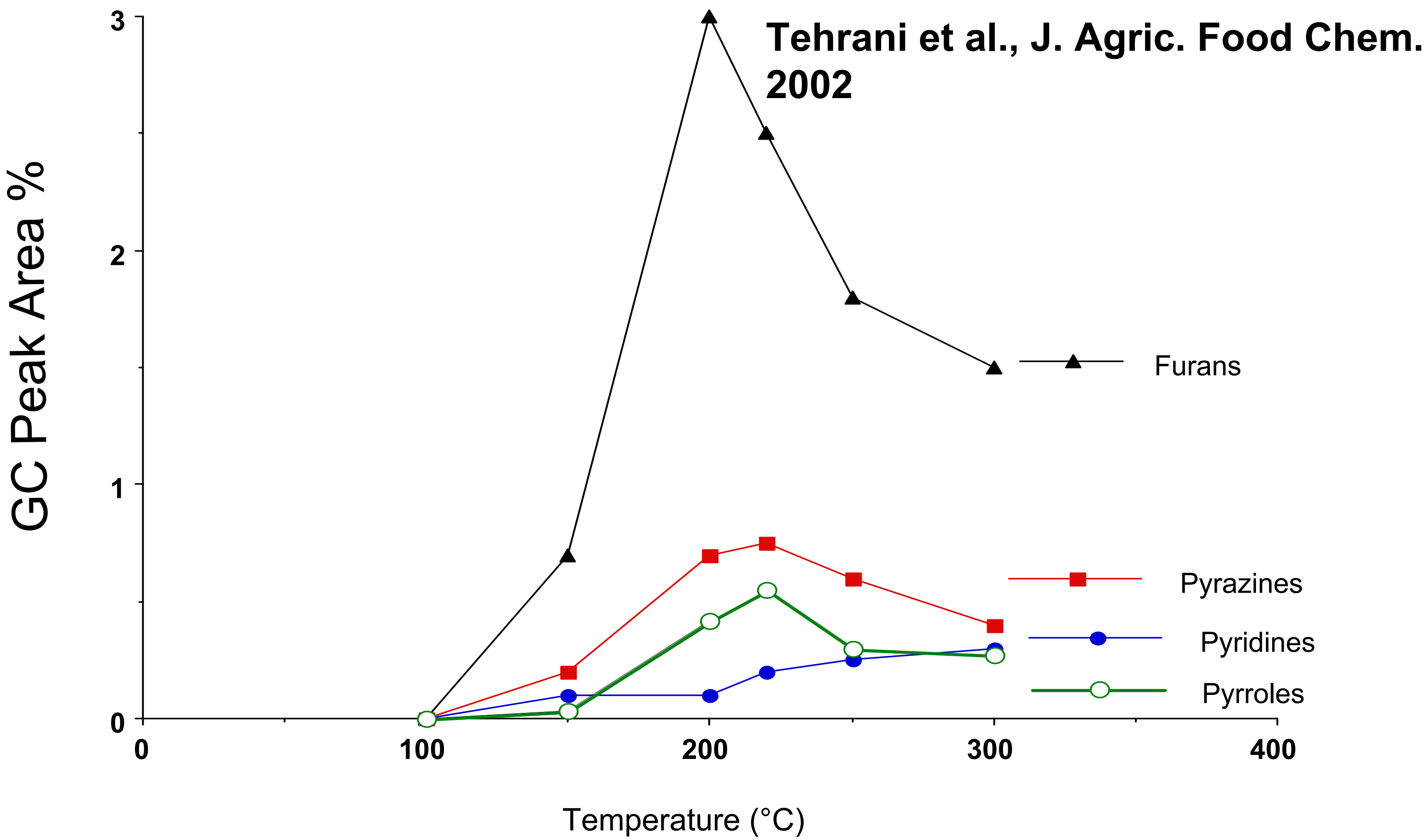
More Work Will Be Done on Acrylamide Formation Mechanisms

- Most current research on formation mechanisms uses model systems based on individual chemical reactants; much more research remains to be done on additional model systems
- Research on actual food is only just beginning
- The impact of various formation mechanisms on acrylamide formation in cooking actual food is not clear
- It may be impossible to identify every acrylamide formation mechanism by current conventional organic reaction mechanisms because acrylamide formation in food is at extremely low levels
- Therefore, controlling any particular mechanism, if possible, may not result in controlling final acrylamide levels in food
    - Impossible to predict the effect of modulation efforts on unknown acrylamide formation mechanisms
    - Some modulation efforts conceivably could increase acrylamide formation from other unknown mechanisms

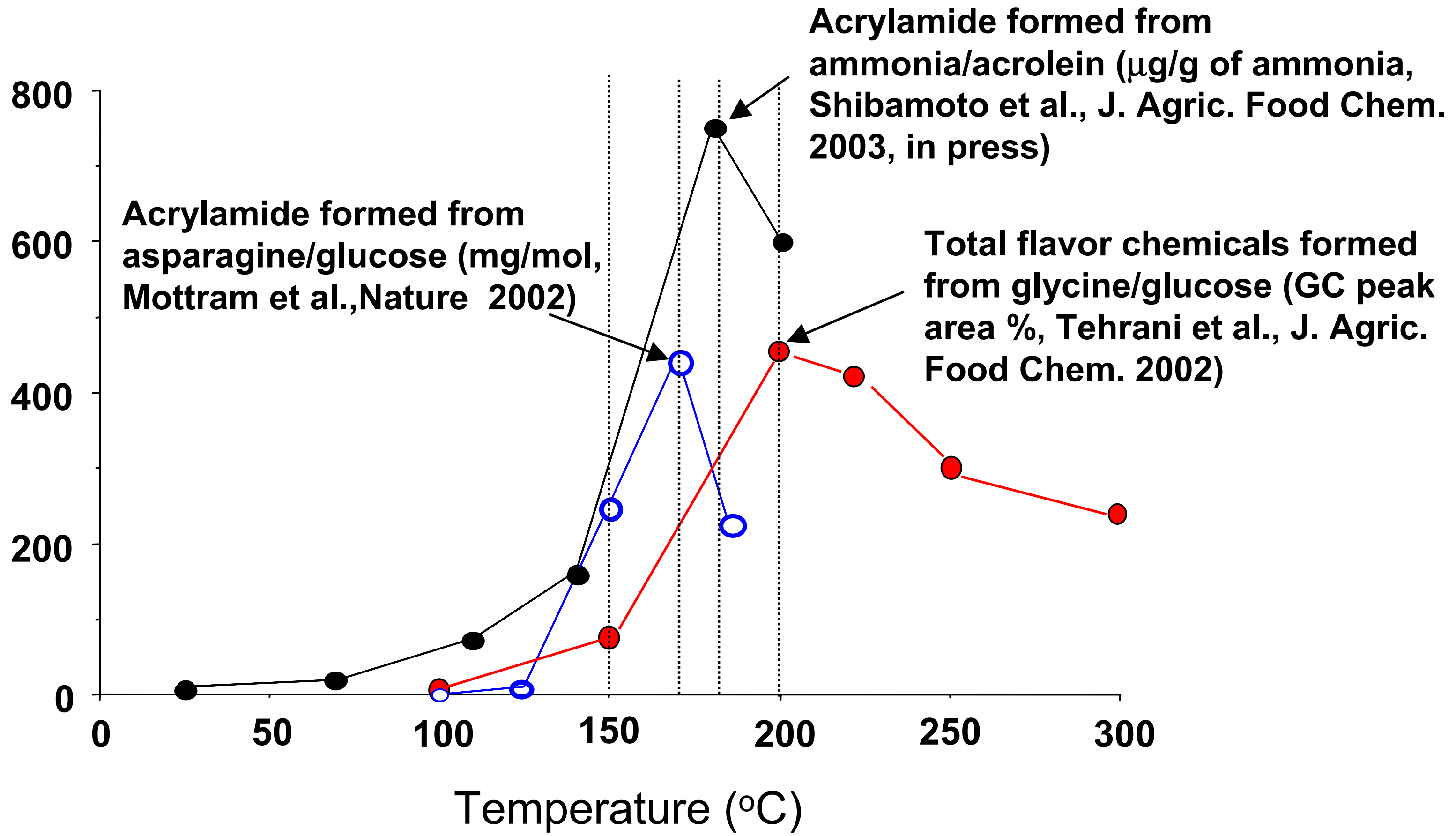
What Does The Current State of Research Mean for Possible Modulation of Acrylamide Levels in Food by Cooking Practices?

- **Current research shows that acrylamide formation is closely related to temperature**
- **But recall that browning also forms palatability and health-beneficial chemicals**
- **Formation of these desirable chemicals also is closely related to temperature**
- **Modulation of acrylamide formation by reduction of cooking temperatures will unavoidably result in loss of palatability and health-beneficial chemical formation**

Influence of Temperature on Formation of Flavor Chemicals Formed from Glycine/Glucose Maillard Model System



Formation of Acrylamide and Flavor Chemicals in Browning Reaction



Temperature Modulation May Not Be Practical or Effective

- Temperatures can vary by 10s of degrees within a single cooking process, even with the best process controls
  - Uniform cooking temperature within a single production lot of cooked food may not be achievable with current technology, especially in restaurant settings
- Reduction of temperature to reduce acrylamide also reduces production of beneficial chemicals
  - Temperature modulation will not impact only acrylamide production
- Reduction of temperature will impact palatability – which will affect consumer preferences, with unknown nutritional results
  - Impact of temperature on production of chemicals related to palatability is well-documented

Temperature Modulation May Not Be Practical or Effective

- **Setting specified temperature modulation requirements may not be effective or achievable**
  - **Multiple chemical production pathways may make specific temperature modulation efforts ineffective in reducing acrylamide levels in cooked food**
  - **Current cooking technology may not be capable of providing sufficiently precise temperature control to implement temperature modulation**
- **Setting specified temperature modulation requirements may have unknown results on consumers**
  - **Customers may override temperature modulation with individual cooking requests**
  - **Negative impact of temperature modulation on palatability will cause unpredictable changes in consumer choice and may have unpredictable effects on nutrition**